Exploring LifeLines to Visualize Patient Records

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LifeLines provide a general visualization environment for personal histories. We explored its use for medical patient records. A one screen overview of the record using timelines provides direct access to the data. Problems, hospitalization and medications can be represented as horizontal lines, while icons represent discrete events such as physician consultations (and progress notes) or tests. Line color and thickness can illustrate relationships or significance. Techniques are described to display large records. Rescaling tools and filters allow users to focus on part of the information, revealing more details.

INTRODUCTION

Computerized medical records pose tremendous problems to system developers. Infrastructure and privacy issues need to be resolved before physicians can even start using the records. Non-intrusive hardware is required for physicians to do their work (i.e. interview patients) away from their desk and cumbersome workstations. But all the efforts to solve those problems will only succeed if appropriate attention is also given to the user interface design [1][8]. Long lists to scroll, clumsy search, endless menus and lengthy dialogs will lead to user rejection. But techniques are being developed to summarize, filter and present large amount of information, leading us to believe that rapid access to needed data is possible with careful design.

While more attention is now put on developing standards for gathering medical records we found that very little effort had been made to design appropriate visualization and navigation techniques to present and explore personal history records. An intuitive approach to visualizing histories is to use graphical time series. The consistent, linear time scale allows comparisons and relations between the quantities displayed. Data can be graphed on the timeline to show time series of quantitative data. Highly interactive interfaces turn the display into a meaningfully structured menu with direct access to the data needed to review a problem or conduct the diagnosis.

RELATED WORK

The use of overviews or summaries has been well studied: the Summary Time-Oriented Record, a pure text flowchart, was found helpful in an arthritis clinic [10]. Another text summary record uses scaled values to indicate the severity of a symptom and also notes the duration of the symptoms, allowing the timing of clinical events to become apparent [11]. Intensive care summary visualization software includes notions of filtering, severity scaling, and details on demand [2].

Tufte [9] describes timelines as a frequent and powerful form of graphic design and presents many examples. Timelines have been used for presenting specific cases in reports and studies [5][7]. A design using timelines for medical records was proposed by Powsner and Tufte [6] who developed a graphical summary using a table of individual plots of test results and treatment data. But little has been proposed to present interactive personal histories. Our work on the visualization of personal history started with a project with the Maryland Department of Juvenile Justice (DJJ). We developed LifeLines to represent youth records (including, cases, placements, worker assignments and reviews) [11]. LifeLines were designed to 1) present a youth record overview on a single screen, 2) provide direct access to all detailed information from the overview with one or two clicks of the mouse, 3) promote critical information or alerts to the overview level. An experiment in home automation showed that timelines could be quickly understood by novice users and used for data entry when scheduling devices in the home [4].

EXPLORING LIFELINES

As a first step we used a simple medical record found on the Internet and prepared a screen mockup of the LifeLine overview of the record [Figure 1]. This mockup was reviewed by several physicians and their feedback encouraged us to explore further. We then worked with a cardiologist who reviewed one of his patient record and designed the interface with us. We are now in the process of rapid prototyping the design. Figures 2 to 4 are screen prints from the prototype.

An idealized scenario

This medical record (Figure 1) spans from 1990 to 1995 and shows on a series of timelines consultations and tests, a list of medical conditions, documents, hospitalizations and medications. Each physician is assigned a different color (not seen on the B&W figure) tying documents and medications to the originating physician. Icons are used for discrete events, lines for continuous items such as conditions or hospital stays. The size of the line is used to indicate changes in the severity of conditions or the dosage of medications. The right most side of the timelines give the current status showing the active conditions. The area at the top of the screen gives general information about the patient. By default alerts such as known allergies are shown on the top right of the LifeLines (In Figure 1 a user already selected another tab to read the contact information).

Each element of the display acts as a "giant" menu to access the detailed information about the item selected. A click on a consultation brings the progress note, a click on a lab test displays the results of the test. A click on a doctor's name brings up the contact information. The detail information may cover part of the display but if a large screen is available it will appear in side windows. Tiled windows allow parallel review (e.g. a lab test and a letter, or a recent lab test and 2 older ones). The respective size of the tiled windows can be adjusted by dragging the sides of the windows.

Dealing with complex records

In our previous work for the Maryland department of Juvenile Justice [3] we explored mechanisms to handle complex records. Crowding problems arise when the time span, the number of categories, the number of lines or the number of events increases significantly. Scroll bars are the common answer to pixel shortage but scroll bars are inadequate - if not harmful - when presenting overviews as users often forget to browse the complete image. We believe that LifeLines should always begin with an overview of the entire record in one screen even if some details are lost in this first view.

In the case of DJJ, some juvenile records contain dozens of cases whose lines cannot be shown on the overview screen. We proposed to present the silhouette of the record (compacted lines with no labels, but color and size coding for severity and deepness of penetration in the legal system). Those silhouettes were found to be useful to estimate the volume and type of information available and to guide users to the most important parts of the records (e.g. a few serious cases lost in myriads of less important offenses). Users can explore the silhouette dynamically, revealing details about the cases as they move the cursor above the lines. When users have appreciated the overview they can access the relevant information directly, zoom on a time period of interest, or filter the display to show only relevant information.

In the case of the medical record, the silhouette of a record might be useful when a physician sees the record for the first time, then a simple click zooms the silhouette to show the current time period and possibly filter on a subset of categories chosen in the physician's preference control panel. The record would appear in the zoomed state during following visits. Another technique is to use a logarithmic scale to emphasize recent events.

Categories of data can be organized in a hierarchy (as shown in Figure 1 - left side) which can be expanded or contracted to filter out some of the data.

Finally smaller icons can be used to display a larger number of events information . In the silhouette a single pixel can represent a visit or a test, giving a sense of the periodicity of the events; and color can indicate type or importance.

Cardiology record design

In this design (Figure 2) the specialist who worked with us elected to display only a subset of the information in the overview screen (problems and interventions) giving more space for the progress notes and current medications. The exact choice of what information is presented on the LifeLines in the overview is selected by the user. Tests are available on top of the timelines. A click on the EKG tab brings the last EKG (with a "previous" button to review previous EKGs), a click on lab brings the last lab test. A click on a PTCA of the interventions line brings the report and an hand-drawn diagram associated with the intervention (Figure 3). The LifeLine of the medication history appears when clicking on "med. history" next to the current medication. In certain cases users might choose to display specific quantitative data e.g. cholesterol levels over the whole span of the overview to see changes over the years. But more likely the physician will decide to zoom in onto a period of interest and see more details. In Figure 4 the physician zoomed to the 1990 period. The zoomed display now reveals the tests available (a click on any one brings the data) and the medications lines. Here the user also asked to show the three cholesterol levels plotted on one line in order to verify that the medications used at that time had been effective in lowering the cholesterol levels. The LifeLines can be scrolled to later time periods if needed.

DATA ENTRY

Many events only require to be time stamped on the timeline. Test results can be received by an office clerk, scanned and marked as test results of a given type, if not transferred automatically.

Those events require little or no input, merely leaving their footprints on the LifeLines for easy retrieval of the information. Major summary items (problems, treatments) are found in the progress notes which are often dictated by the physician and typed by a trained secretary. Codes can be added to the progress notes or lines can be entered by the trained secretary for review along with the notes by the physician.

CONCLUSION

Personal histories contain information that plays an important role in critical decision making. However, problems are associated with current methods of presenting the information to physicians. The proposed solution, LifeLines, charts the course of a personal history across time using lines to mark periods and icons to denote events of that history.

Acknowledgments

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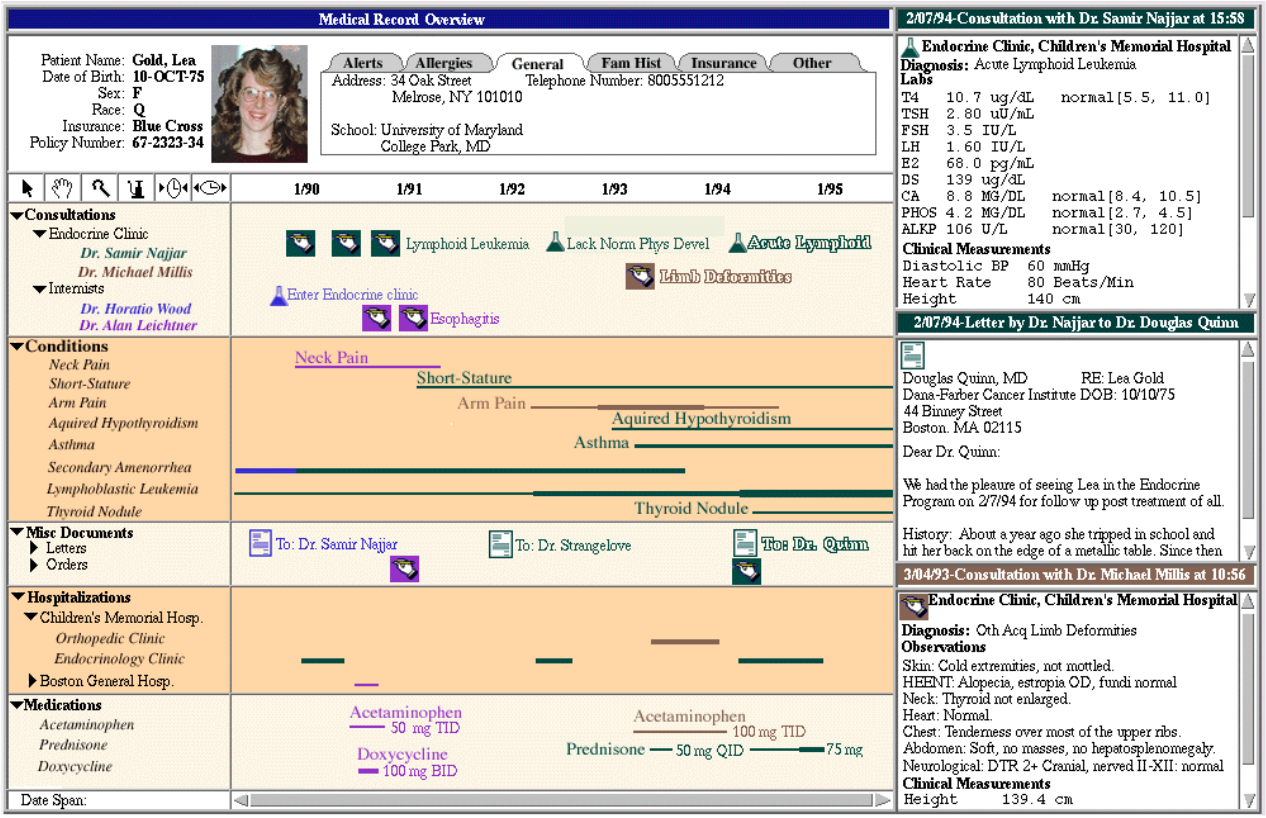

Figure 1: Simple medical record showing all physician visits, conditions, hospitalizations and medications. Every item in the record is seen as a line or icon in the overview. Side windows show details for review.

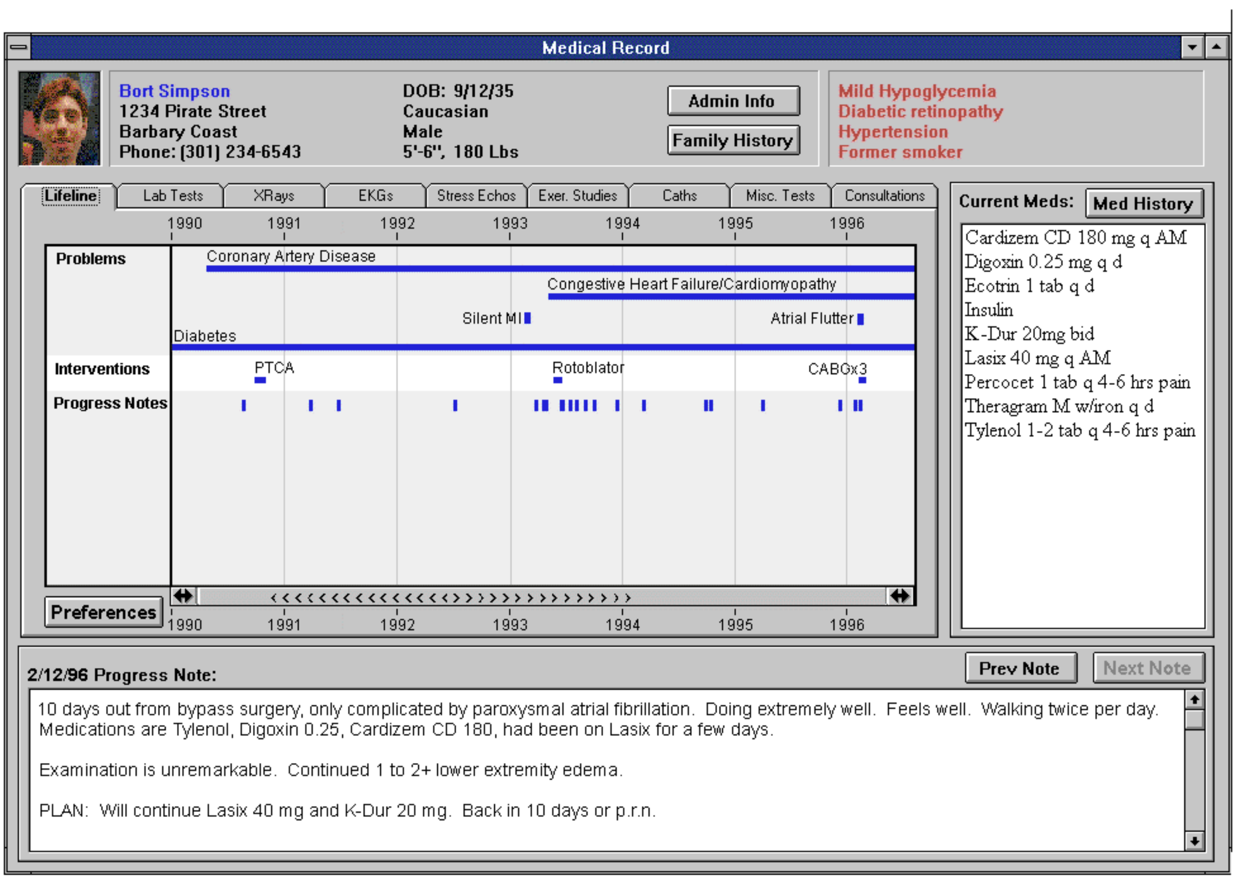

Figure 2: A cardiology patient record showing problems and interventions, the last progress note and current medications.

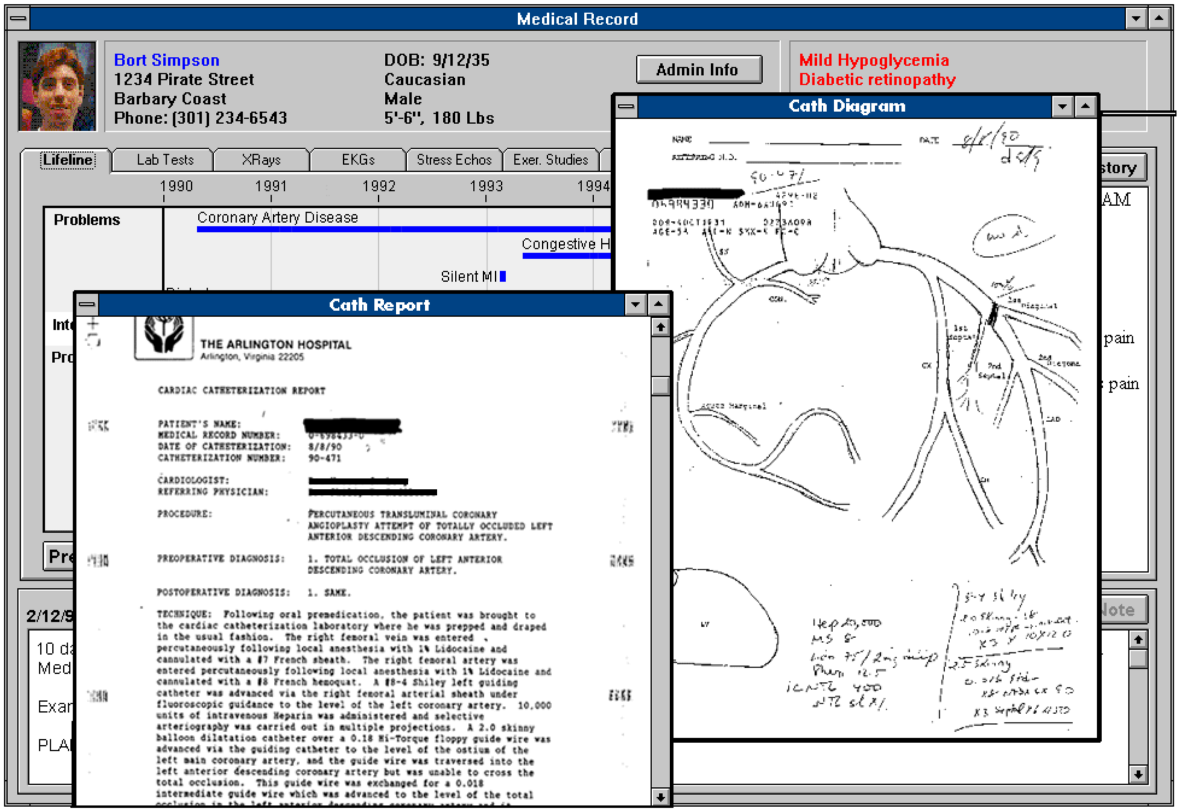

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Figure 3: When a user clicks on the 1990 PTCA (Figure 2), intervention reports are shown.

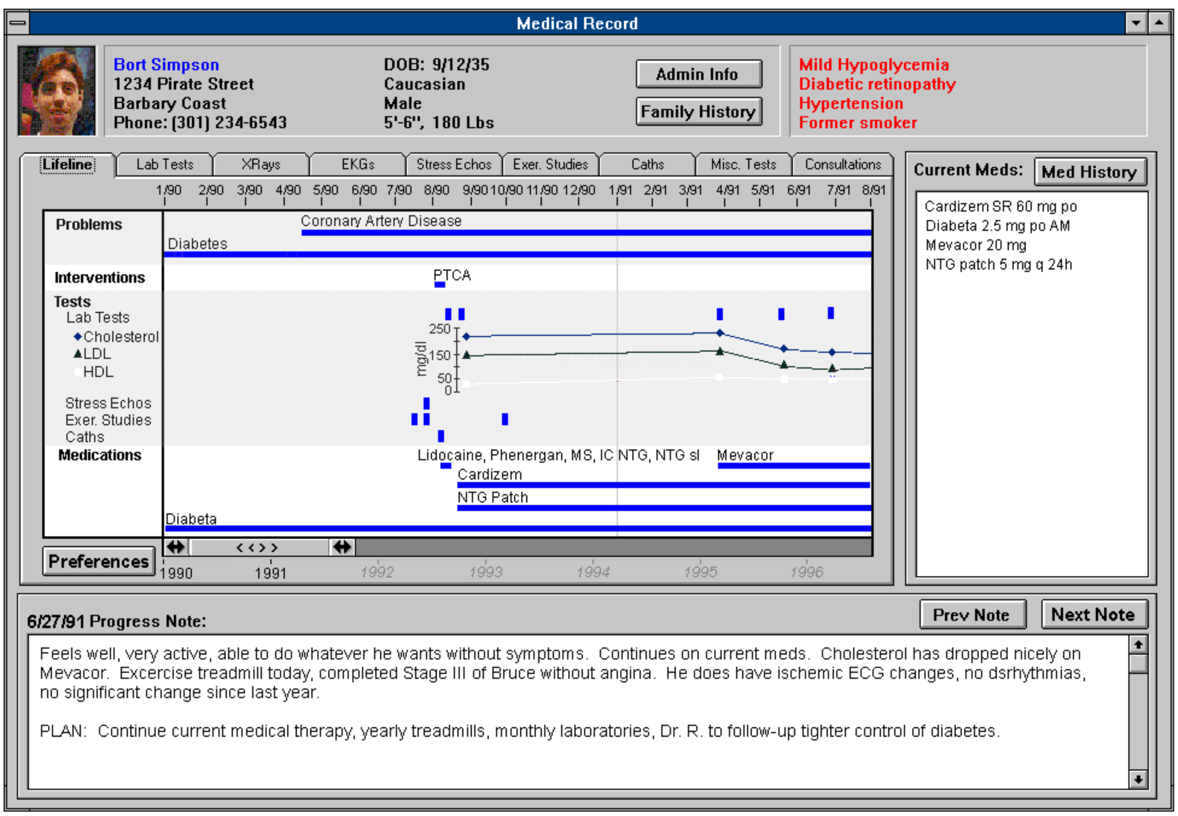

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Figure 4: Here a user has zoomed the LifeLines to study the 1990-1991 period. The tests given and the medications prescribed are shown. To check the effectiveness of the medications, cholesterol levels were selected to be plotted on the LifeLines (using the Preference menu)